(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 568 053 B1

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
02.07.1997 Bulletin 1997/27

(51) Int. Cl.[6]: C03B 23/025, C03B 25/08, C03B 29/08

(21) Application number: 93106922.3

(22) Date of filing: 28.04.1993

(54) Method and apparatus for bending and tempering a glass sheet

Verfahren und Vorrichtung zum Biegen und Härten von Glasscheiben

Procédé et dispositif pour bomber et tremper les feuilles de verre

(84) Designated Contracting States:
CH DE FR GB IT LI

(30) Priority: 30.04.1992 FI 921964

(43) Date of publication of application:
03.11.1993 Bulletin 1993/44

(73) Proprietor: Tamglass Engineering Oy
SF-33730 Tampere (FI)

(72) Inventors:
- Vehmas, Jukka Heikki
SF-33420 Tampere (FI)
- Paavola, Juha
SF-33820 Tampere (FI)

(74) Representative: Grünecker, Kinkeldey, Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(56) References cited:
EP-A- 0 132 701
EP-A- 0 233 778
EP-A- 0 370 313
US-A- 3 166 397

EP 0 568 053 B1

Description

The present invention relates to a method for bending and tempering a glass sheet, in which method a glass sheet supported by a ring mould is heated to the softening temperature in at least one preheating station, the, glass sheet is allowed to bend gravitationally and the bent glass sheet is further advanced to tempering.

The invention relates also to an apparatus for bending and tempering a glass sheet, said apparatus comprising a ring mould for supporting a glass sheet in various working operations, at least one preheating station, a bending station and a quenching station.

The invention is particularly well suited for bending relatively simple glass shapes which can be bent gravitationally by using a ring mould. Most of the automotive side windows and backlights are of such simple shapes or forms that they can be bent by using the method and apparatus or the invention. For essentially the same purpose there is a prior known method, wherein a piece of hemothermal glass is dropped onto a ring mould and the piece of glass assumes its proper form by virtue of inertial force and the shape of the ring mould. This prior known method offers the advantages of high capacity and reliability but its drawbacks include a high price, a rather long form replacement time (4-5 h), marks caused by dropping on the glass border areas, and the high price of tools required by individual pieces of glass.

On the other hand, there are known single furnaces operating on the ring mould principle, wherein the glass is only heated from above and the glass bends to its shape or form whose bending depth is determined by adjusting the heating time (see e.g. EP-A-0 132 701). An advantage offered by single furnaces is a simple construction and a low price but there are also drawbacks, including a low capacity, a relatively high minimum thickness (typically 5 mm, sometimes 4 mm), simple bending shapes and fairly good bending accuracy (as the bending depth is only controlled by means of the heating time).

An object of the invention is to provide an improved method and apparatus, capable of offering the following benefits:

- economical price in view of capacity
- a reachable glass thickness is substantially below 4 mm, typically a 3,2 mm minimum thickness or therebelow
- compact size of the apparatus
- low tooling costs (e.g., only four ring moulds are required for a glass pattern)
- a short glass-pattern replacement time (typically less than 0,5 h).

This object of the invention is achieved by the method of claim 1 and the apparatus of claim 8.

One embodiment of the invention will now be described in more detail with reference made to the accompanying drawing, in which

fig. 1 shows schematically a lengthwise vertical section through a furnace of the invention and

fig. 2 shows schematically a lengthwise horizontal section through the same furnace.

Fig. 3 shows a detail in a bending station 8.

In a loading station 1 a glass sheet to be bent is placed on top of a ring mould 3. The ring mould 3 is advanced upon a carriage 2 along a lower horizontal track 4 into a preheating station 5, fitted with resistances 7 for heating a glass sheet from above by the application of radiation heat. Thereafter, said carriage 2 along with its mould 3 and glass sheet is shifted to below a preheating station 6 and is lifted by means of a hoist into said preheating station 6, wherein the heating is continued by means of resistances 7. As known in the art, the preheating can be effected at a relatively rapid rate since heat transfers effectively to cold glass. In preheating, a glass sheet typically reaches a temperature of about 500°C. Naturally, the final temperature of preheating can fluctuate considerably one way or the other. The preheated glass along with its ring mould 3 is advanced into a bending station 8, which at the same time serves as an effective heating chamber having a temperature of appr. 900°C. The temperature of heating and bending chamber 8 can typically fluctuate within the range of 800-1000°C. Said chamber 8 is provided with powerful resistances 9 for heating a glass sheet so quickly that a piece of 4 mm glass heats from 500°C within about 15-20 seconds up to a tempering temperature of 600-630°C, typically 615-620°C. During this rapid heating the glass is simultaneously allowed to bend. Thus, e.g. with 4 mm glass, the temperature increase rate is preferably about 6-8°C/s, i.e. generally about 24-32°C/mm/s. In order to achieve the object of the invention, the temperature increase rate should be at least appr. 15°C/mm/s.

The glass temperature is monitored by means of a pyrometer and/or the bending flexure by means of an optical apomecometer device 10. Therefore, the heat insulation of the furnace ceiling is provided with an observation window 11. When pyrometer and/or flexure measuring device 10 detects that a predetermined glass temperature and/or bending flexure has been reached, the glass is carried as quickly as possible to tempering. The passage from bending station 8 to a tempering station 13 is effected on the same ring mould 3 along a track 12. In tempering station 13, both sides of a glass sheet are subjected to the action of cooling air jets. This can be accomplished by using upper and lower manifolds 14 and 15, whose ends can be either on a straight line or can be set according to an anticipated, compromised bending form. From tempering station 13 the glass and its mould 3 are transferred into an unloading station, wherein the tempered glass is removed from ring mould 3. This is followed by placing the next piece

of glass on top of the ring mould and the glass, together with its ring mould, is advanced into the preheating station.

Ring mould 3 is supported on carriage 2 from outside and it is coated with a fibrous coating suitable for glass bending and tempering.

The movements of carriage 2 along tracks 4 and 12 are produced e.g. by means of a system described in US Patent publication 4 497 645 by using carriages mounted on wheels rotatable from outside the furnace.

The bending station 8 serving as a power heating chamber is the heart of an apparatus of the invention. A novel feature therein is high-speed heating facilitated by a high temperature, appr. 900°C. The bending of glass can be effected without the application of heat by means of a ring mould to a desired shape. This applies to simple glass shapes but, as the shape reaches a higher degree of complexity, the glass thickness decreases and the glass size increases, there will be more and more difficulties in producing a desired shape or form. Close control of the glass temperature and/or degree of bending and a possibility of moving the glass quickly to tempering make sure, however, that a method and apparatus of the invention are capable of readily and controllably bending flexural forms that are conventional in automotive backlights and side windows.

A method of the invention facilitates particularly the bending and tempering of thin (3-4 mm) pieces of glass as bending does not begin until the tempering temperature is just exceeded; as soon as a desired shape is obtained, the glass can be advanced directly to tempering. In the cases of lower-temperature furnaces this is not possible, since the central glass area has already had enough time to sag or bend further than a desired shape by the time the tempering temperature is reached.

When using a ring mould for supporting a piece of glass throughout the heating operation, the result will be that the border or edge areas of glass remain colder than the rest of the glass. The reason for this is that, by virtue of its mass and thermal capacity, a ring mould shall remain colder than glass and, thus, it receives heat from glass. If a piece of glass is to be tempered, the entire glass must be thoroughly heated to above the tempering temperature and, thus, the central glass areas will become unnecessarily hot. This, in turn, leads to uncontrollable over-bending of the central glass areas.

If the effect of ring mould 3 on a slower heating rate in the border area of a glass sheet cannot be eliminated or compensated by a further heating of the border area, the glass will be heated over its central area to 10-20°C unnecessarily high temperature in order to temper the border area as well (or just to keep the glass intact). Considering the common rule that the bending rate of glass doubles as the glass temperature increases by 8°C, it is possible to understand the problem caused by the cooling effect of a ring mould.

In order to eliminate this problem, the invention suggests that the heating of a glass sheet in bending station 8 be intensified by using forced convection at least in the glass sheet border areas supported by ring mould 3. This is illustrated in fig. 3.

Thus, the glass border or edge area is heated more to equalize the cooling effect of a ring mould, but no more than that. The objective is to obtain a completely hemothermal piece of glass.

The technical solution is carried out by using compressed air jets which are blasted from tubes 17 and/or 18 fitted adjacent to the border area. From the lower tube 17 the air jets are blown vertically upwards (possibly at a 15° angle) in a manner that the air jet does not hit the glass but the border area and ring mould 3 are heated by a vortex formed by the air jets. Since the demand for supplementary heat is slight, just one of the tubes, e.g. lower tube 17, is probably needed. In practice, the manifold is not a continuous loop but divided into a plurality of individually controlled zones.

Tests have shown that mere radiation heating is not always capable of sufficiently heating the top surface of glass but, instead, the bottom side heats more even though the bottom side would not be actually heated at all. This can be compensated by utilizing convection blasting if necessary over the entire surface area of a glass sheet in view of compensating for the heating of either top or bottom surface.

As already pointed out, the bent piece of glass heated to a tempering temperature is advanced as quickly as possible to tempering. This is important since, once outside a furnace, the 4 mm glass cools prior to tempering at a rate of appr. 5°C/s. Every "wasted" second results in unnecessary over-heating of glass by 5°C. Therefore, the quenching blast should already be switched on and the nozzles should be in a proper position when the glass is brought to tempering. If tempering of all glass shapes cannot be performed by a single manifold or nozzle system, said manifolds 14, 15 can be made replaceable. In the simplest of embodiments, said manifolds or nozzle systems 14, 15 comprise folded and perforated plates. For example, four different manifolds (perforated plates) folded to various shapes will be sufficient to cover the entire area. Naturally, it would also be possible to employ an adjustably shaped manifold (adjustment can be manual).

As described above, an apparatus of the invention is very simple in its technical construction and thus economical in its costs. Nevertheless, in view of its price and size, said apparatus yields a very high production capacity (60-120 loadings/h).

Claims

1. A method for bending and tempering a glass sheet, in which method the glass sheet supported by a ring mould (3) is heated to the softening temperature in at least one preheating station, the glass sheet is allowed to bend gravitationally in a bending station (8), and the bent glass sheet is further

advanced for tempering in a tempering station (13), **characterised in that** above the glass temperature of 500°C the heating of the glass sheet to the tempering temperature is effected in the bending station at such a heating rate that 4 mm glass heats from the temperature of 500°C to the tempering temperature of 600-630°C in less than 28 seconds, preferably within about 15-20 seconds, whereby the temperature increase rate of the glass sheet at least at the glass surface is in average at least appr. 15°C/mm/s, preferably 24-32°C/mm/s.

2. A method as set forth in claim 1, **characterized in that** said temperature increase rate is 24-32°C/mm/s or 6-8°C/s on 4 mm glass.

3. A method as set forth in claim 1 or 2, **characterised in that** the bending flexure or temperature of the glass sheet is measured and, upon reaching a predetermined bending flexure or temperature, the glass sheet is further advanced for tempering supported by the same ring mould (3).

4. A method as set forth in any of claims 1-3, **characterised in that** prior to passing the glass sheet into the bending station (8), the preheating of the glass is effected on two levels, first on a lower level (station 5) and then, after hoisting said ring mould (3), on an upper level (station 6), and that the glass is carried on the same ring mould (3) to the bending station and the tempering station (13).

5. A method as set forth in claim 1 or 2, **characterised in that** in the bending station (8) the heating of the glass sheet is intensified by forced convection.

6. A method as set forth in claim 5, **characterised in that** boosted convection is applied at least to the border areas of the glass sheet, which are supported by the ring mould (3).

7. A method as set forth in claim 6, **characterised in that** the boosted convection is applied to the border areas of the glass sheet in a manner that the blasting jets are directed past the edge of the glass sheet adjacent to the edge of the glass sheet.

8. An apparatus for bending and tempering a glass sheet, said apparatus comprising a ring mould (3) for supporting a glass sheet in various working operations, at least one preheating station (5, 6), a bending station (8), and a tempering station (13), **characterised in that** said
bending station (8) is provided with heating means adapted for bringing the temperature of the bending station at a temperature of at least 100°C, preferably over 200°C higher than the temperature to which the glass sheet is heated for tempering, and with measuring means (10) for measuring the bending flexure or temperature of the glass sheet and these measuring means (10) are adapted to commence the passage of the ring mould (3) and the glass sheet supported thereby from the bending station (8) into the tempering station (13),
and wherein two preheating stations (5, 6) are provided which are located on two different vertical levels in a manner that one preheating station (5) lies below the bending station (8) and the other preheating station (6) lies adjacent to the bending station (8).

9. An apparatus as set forth in claim 8, **characterised in that** the temperature of the bending station is about 800-1000°C and the tempering temperature of the glass sheet is about 600-630°C, at which temperature the glass sheet is advanced from the bending station (8) into the tempering station (13).

Patentansprüche

1. Verfahren zum Biegen und Härten einer Glasscheibe, wobei die auf einer Ringform (3) gestützte bzw. gelagerte Glasscheibe auf die Erweichungstemperatur in wenigstens einem Vorwärmbereich erwärmt wird, sich die Glasscheibe durch Schwerkraft in einem Biegebereich (8) biegt, und die gebogene Glasscheibe weiter zum Härten in einen Härtebereich (13) befördert wird, **dadurch gekennzeichnet**, daß oberhalb der Glaztemperatur von 500°C das Erwärmen der Glasscheibe zu der Härtetemperatur in dem Biegebereich mit solch einer Aufheizgeschwindigkeit durchgeführt wird, daß sich 4 mm dickes Glas von der Temperatur von 500°C auf die Härtetemperatur von 600 bis 630°C in weniger als 28 Sekunden erwärmt, vorzugsweise innerhalb von 15 bis 20 Sekunden, wodurch die Temperaturanstiegsgeschwindigkeit der Glasscheibe wenigstens an der Glasoberfläche durchschnittlich wenigstens ungefähr 15°C/mm/s, vorzugsweise 24 bis 32°C/mm/s beträgt.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet**, daß die Temperaturanstiegsgeschwindigkeit 24 bis 32°C/mm/s oder 6 bis 8°C/s bei 4 mm dickem Glas beträgt.

3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet**, daß die Durchbiegung oder Temperatur der Glasscheibe gemessen wird und beim Erreichen einer vorbestimmten Durchbiegung oder Temperatur die Glasscheibe des weiteren zum Härten befördert wird, gestützt auf der gleichen Ringform (3).

4. Verfahren nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet**, daß, bevor die Glasscheibe in den Biegebereich (8) befördert wird, das Vorwärmen der Glasscheibe auf zwei Ebenen

durchgeführt wird, zunächst auf einer unteren Ebene (Bereich 5) und anschließend, nachdem die Ringform (3) heraufgezogen wurde, auf einer oberen Ebene (Bereich 6), und daß die Glasscheibe auf der gleichen Ringform (3) zu dem Biegebereich und dem Härtebereich (13) befördert wird.

5. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet,** daß in dem Biegebereich (8) das Erwärmen der Glasscheibe durch Zwangskonvektion verstärkt wird.

6. Verfahren nach Anspruch 5, **dadurch gekennzeichnet,** daß eine Hilfs- bzw. Zusatzkonvektion auf wenigstens die Randbereiche der Glasscheibe ausgeübt wird, welche von der Ringform (3) gestützt wird.

7. Verfahren nach Anspruch 6, **dadurch gekennzeichnet,** daß die Hilfs- bzw. Zusatzkonvektion auf die Randbereiche der Glasscheibe in solch einer Weise angewandt wird, daß Strahldüsen vor die Kante der Glasscheibe in der Nähe der Kante der Glasscheibe gerichtet werden.

8. Vorrichtung zum Biegen und Härten einer Glasscheibe, wobei die Vorrichtung umfaßt:
eine Ringform (3), um eine Glasscheibe in verschiedenen Arbeitsstellungen abzustützen, wenigstens einen Vorwärmbereich (5, 6), einen Biegebereich (8), und einen Härtebereich (13), **dadurch gekennzeichnet**, daß
der Biegebereich (8) mit Heizeinrichtungen versehen ist, welche geeignet sind, die Temperatur des Biegebereichs auf eine Temperatur von wenigstens 100°C, vorzugsweise über 200°C oberhalb der Temperatur, auf welche die Glasscheibe zum Härten erwärmt wird, zu erhöhen, und mit Meßeinrichtungen (10) zum Messen der Durchbiegung oder der Temperatur der Glasscheibe und wobei diese Meßeinrichtungen (10) geeignet sind, den Durchgang der Ringform (3) und der von dieser abgestützten Glasscheibe von dem Biegebereich (8) in den Härtebereich (13) zu beginnen,
und wobei zwei Vorwärmbereiche (5, 6) bereitgestellt sind, welche an unterschiedlichen vertikalen Ebenen angeordnet sind, in solch einer Weise, daß ein Vorwärmbereich (5) unterhalb des Biegebereichs (3) und der andere Vorwärmbereich (6) neben dem Biegebereich (8) liegt.

9. Vorrichtung nach Anspruch 8, **dadurch gekennzeichnet,** daß die Temperatur des Biegebereichs ungefähr 800 bis 1000°C beträgt und daß die Härtetemperatur der Glasscheibe ungefähr 600 bis 630°C beträgt, wobei die Glasscheibe bei dieser Temperatur von dem Biegebereich (3) in den Härtebereich (13) befördert wird.

Revendications

1. Procédé pour bomber et tremper une feuille de verre, dans lequel on chauffe la feuille de verre supportée par un moule en forme d'anneau (3) à la température de ramollissement dans au moins un poste de préchauffage, on laisse la feuille de verre se bomber par gravité dans un poste de bombement(8), puis on fait avancer la feuille de verre bombée pour la tremper dans un poste de trempe (13), **caractérisé en ce qu**'au dessus de la température de verre de 500 °C, le chauffage de la feuille de verre à la température de trempe est effectué dans le poste de bombement à une vitesse de chauffage telle qu'un verre de 4 mm chauffe de la température de 500 °C à la température de trempe de 600 à 630 °C en moins de 28 secondes, de préférence en l'espace d'environ 15 à 20 secondes, de sorte que la vitesse d'augmentation de la température de la feuille de verre, au moins à la surface du verre, soit en moyenne d'au moins approximativement 15 °C/mm/s, de préférence 24 à 32 °C/mm/s.

2. Procédé selon la revendication 1, **caractérisé en ce que** ladite vitesse d'augmentation de température est de 24 à 32 °C/mm/s ou 6 à 8 °C/s sur un verre de 4 mm.

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** la flexion du bombement ou la température de la feuille de verre est mesurée et, après avoir atteint une flexion du bombement ou une température prédéterminée, on fait ensuite avancer la feuille de verre pour la tremper, supportée par le même moule en forme d'anneau (3).

4. Procédé selon l'une quelconque des revendications 1 à 3, **caractérisé en ce qu**'avant de faire passer la feuille de verre dans le poste de bombement (8), le préchauffage du verre est effectué sur deux niveaux, d'abord sur un niveau inférieur (poste 5) puis, après avoir hissé ledit moule en forme d'anneau (3), sur un niveau supérieur (poste 6), et en ce que le verre est transporté sur le même moule en forme d'anneau (3) au poste de bombement et au poste de trempe (13).

5. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** dans le poste de bombement (8), le chauffage de la feuille de verre est intensifié par une convection forcée.

6. Procédé selon la revendication 5, **caractérisé en ce que** la convection forcée est appliquée au moins aux aires de bordure de la feuille de verre, qui sont supportées par le moule en forme d'anneau (3).

7. Procédé selon la revendication 6, **caractérisé en ce que** la convection forcée est appliquée aux aires

de bordure de la feuille de verre de manière que les jets de décapage soient dirigés le long du bord de la feuille de verre de façon adjacente au bord de la feuille de verre.

8. Appareil pour bomber et tremper une feuille de verre, ledit appareil comprenant un moule en forme d'anneau (3) pour supporter une feuille de verre dans diverses opérations de travail, au moins un poste de préchauffage (5, 6), un poste de bombement (8) et un poste de trempe (13), **caractérisé en ce que** ledit poste de bombement (8) est muni de moyens chauffants adaptés pour porter la température du poste de bombement à une température d'au moins 100 °C, de préférence plus de 200 °C, supérieure à la température à laquelle la feuille de verre est chauffée pour la trempe, et de moyens de mesure (10) pour mesurer la flexion du bombement ou la température de la feuille de verre et ces moyens de mesure (10) sont adaptés pour commencer le passage du moule en forme d'anneau (3) et de la feuille de verre supportée par celui-ci depuis le poste de bombement (8) dans le poste de trempe (13),

et dans lequel deux postes de préchauffage (5, 6) qui sont situés sur deux niveaux verticaux différents sont fournis, de manière qu'un poste de préchauffage (5) se trouve en dessous du poste de bombement (8) et que l'autre poste de préchauffage (6) se trouve adjacent au poste de bombement (8).

9. Appareil selon la revendication 8, **caractérisé en ce que** la température du poste de bombement est d'environ 800 à 1000 °C et la température de trempe de la feuille de verre est d'environ 600 à 630 °C, température à laquelle la feuille de verre est envoyée du poste de bombement (8) au poste de trempe (13).

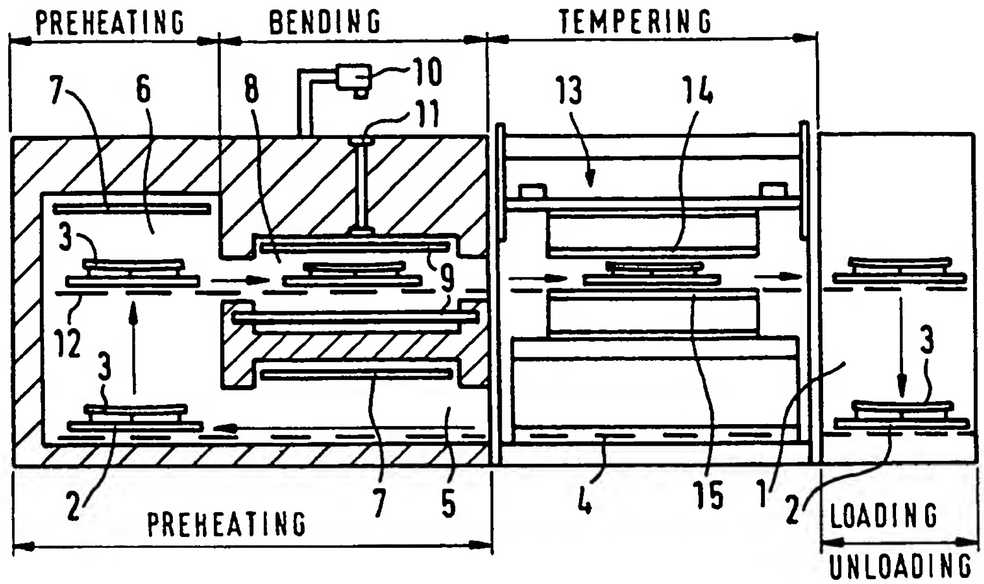
PREHEATING
BENDING
TEMPERING
7
6
8
10
11
13
14
3
9
12
3
3
2
PREHEATING
7
5
4
15
1
2
LOADING
UNLOADING

Fig. 1

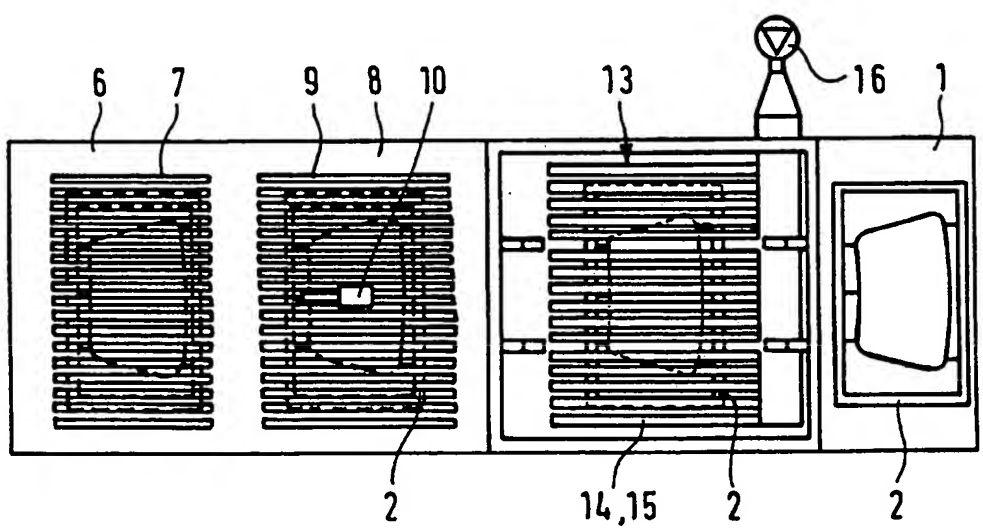
6
7
9
8
10
13
16
1
2
14,15
2
2

Fig. 2

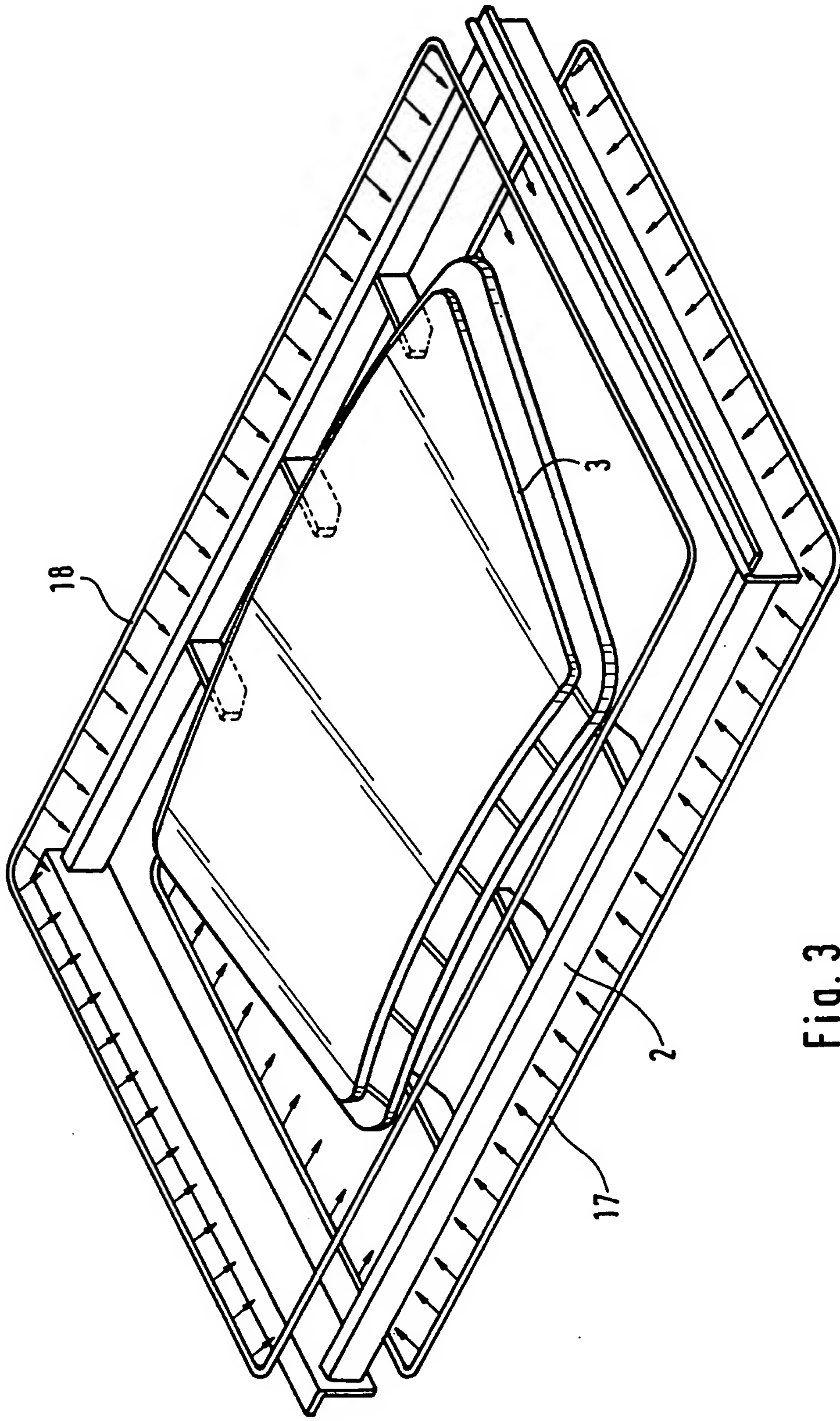

Fig. 3